PHYSICS

Title:

EXPERIMENTAL MEASUREMENT OF THE DISPERSION RELATION OF CAPILLARY WAVES BY LASER INTERFEROMETRY: NON-CONTACT DETERMINATION OF THE SURFACE TENSION OF WATER-ETHANOL BINARY MIXTURES

Adam C Perkins and **Fred Behroozi***

University of Northern Iowa
Department of Physics
Cedar Falls, IA 50614
e-mail: prepared@uni.edu

Abstract:

The current methods of determining surface tension share a common general idea. The Willhelmy plate, the ring, and the rod-pull methods all employ a technique in which a foreign object is placed in the solution being studied. In this study we describe a novel noninvasive method based on laser interferometry to measure the dispersion relation of capillary waves on fluids.

Surface tension and viscosity determine the propagation characteristics and attenuation of capillary surface waves, while gravity plays a minor role. Thus surface tension and viscosity may be found from dispersion and attenuation behavior of the waves. Our system constitutes a new technique for generation and detection of standing and traveling capillary waves. We are able to map the profile, and determine the propagation speed and attenuation of these waves with unprecedented accuracy. Here we describe the system in measuring the surface tension of binary fluids.

Capillary waves are generated electronically by metal blades a short distance above the mixture's surface. A sinusoidal voltage with known frequency is sent through the blades. The polarity of the mixture causes wave trains of the same frequency to propagate. Standing waves are created by using two blades. Accurate measurements of the distance between several nodes determines the wavelength of the capillary waves.

A novel fiber-optic detection system functions as a miniature laser interferometer to measure the amplitude and wavelength of the waves. The heart of the system consists of a single mode fiber, which is positioned vertically and a short distance above the fluid surface. Laser light, traveling through the fiber, reflects back from the tip of the fiber and from the fluid surface. The interference pattern formed by the two reflected light beams is very sensitive to the gap between the fiber tip and the surface of the fluid. As the surface level changes due to the wave motion, the interference signal keeps an accurate record of the change in the gap in real time.

To obtain the surface tension, we measure the velocity of surface capillary waves at several frequencies. This is accomplished by an accurate measurement of the wavelength of standing waves as described above.

We present dispersion data for pure water and a number of water-ethanol binary mixtures with various ethanol concentrations. The surface tension is obtained by a global fit of the dispersion data using the surface tension as an adjustable parameter. Results are compared to the published data on surface tension of pure water and to previous studies and methods that have determined water-ethanol surface tension. Our results are in good agreement with the most reliable data.